Abstract View

Volume 13, Issue 4 (April 1983)

Journal of Physical Oceanography
Article: pp. 695–708 | Abstract | PDF (1.14M)

Hydraulie Control and Flow Separation in a Multi-Layered Fluid with Applications to the Vema Channel

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(Manuscript received November 1, 1982, in final form January 12, 1983)

DOI: 10.1175/1520-0485(1983)013<0695:HCAFSI>2.0.CO;2

ABSTRACT

Observations from a recent field experiment in the Vema Channel are briefly described. These show a remarkable change in the configuration of isopycnal surfaces within the channel and the development of thick, nearly homogeneous regions near the bottom which are capped by sharp vertical gradients. Contrary to previous speculation that these “bottom boundary layer” result from enhanced vertical mixing, a dynamical mechanism is explored. This involves the hydraulic adjustment of an inertial, semi-geostrophic flow to the channel geometry.

First, an active two-layer flow in a rectangular geometry is studied to show that internal flow separation can occur when the flow is accelerated sufficiently by a narrowing channel. Almost always this separation accompanies hydraulic control: the slowest upstream moving Kelvin wave is stopped and upstream and downstream states are not symmetric with respect to the channel width. An active three-layer flow with a variable bottom profile is then presented as a more accurate model of the Vema Channel. The crucial geometrical ingredient appears to be the growth of a plateau on the eastern side of the channel: this confines the deepest layer laterally but it has more of a sill effect upon the upper layers. Many of the observed features of the flow are explained by this model including the changing layer shapes, flow separation, and the reverse flow found above the plateau.

A major disagreement is that the flow in the furthest downstream section does not appear to be separated, but more closely resembles that at the entrance. It is suggested that upstream of this last section a hydraulic jump occurs returning the flow to a subcritical state of lower energy. Consistent with this idea the potential energy of the deeper layers increases, and the wave perturbation amplitudes have the correct tendency.

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